PERFORMANCE OF LIGHTWEIGHT CONCRETE CONTAIN PALM OIL FUEL ASH TOWARDS ELEVATED TEMPERATURE SUBJECTED TO AIR COOLING

IZZATI BINTI MOHD KHALID

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

_____

(Supervisor's Signature)

Full Name :DR KHAIRUNISA BINTI MUTHUSAMY

Position : SENIOR LECTURER

Date : 25 JUNE 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : IZZATI BINTI MOHD KHALID

ID Number : AA14108

Date : 25 JUNE 2018

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ABSTRAK

Kajian ini adalah mengenai kesan kaedah penyejukan pada prestasi konkrit ringan yang mengandungi abu bahan api minyak kelapa sawit yang terdedah kepada suhu tinggi. Kekurangan berat bahan, retak, warna dan kekuatan mampatan konkrit yang mengandungi abu bahan api kelapa sawit (POFA) sebagai pengganti simen selepas terdedah kepada suhu tinggi dan kaedah penyejukan udara disiasat. Dalam kajian ini spesimen konkrit dibuat dari OPC dan campuran konkrit POFA telah disediakan dan tertakluk kepada suhu yang berbeza. POFA digunakan sebagai pengganti simen kerana menghasilkan karbon dioksida yang banyak melalui proses simen yang menyebabkan pemanasan global.Setelah diletakkan di dalam air selama 28 hari, spesimen telah menjalani ujian ketahanan api. Seterusnya, semua spesimen akan ditempatkan di relau elektrik dengan peningkatan suhu 200 ℃, 400 ℃, 600 ℃, 800 ℃ untuk tempoh 1 jam. Sejumlah peratusan POFA adalah 0%, 10%, 20%, 30%, 40%. Spesimen ini tertakluk kepada kaedah penyejukan udara. Kekuatan mampatan didapati lebih tinggi pada 10% konkrit POFA daripada konkrit biasa. Sementara itu penurunan berat konkrit yang tinggi dalam 40% konkrit yang mengandungi POFA pada 800 ℃. Selain itu, semakin tinggi suhu, perubahan warna dan keretakan konkrit lebih ketara.

ABSTRACT

This study is about the effect of cooling method on the performance of lightweight concrete that contain palm oil fuel ash exposed to elevated temperature. The weight loss, crack, color and compressive strength of concrete containing palm oil fuel ash (POFA) as cement replacement after exposed to elevated temperature and air cooling method were investigated. In this study the concrete specimen are made from OPC and mixes of POFA concrete were prepared and subjected to different temperature. POFA were used as cement replacement due to the carbon dioxide produce through cement process which causes global warming. After water cured for 28 days the specimen were subjected to fire resistance test. Next, all the specimen will be place in the furnace electrical with increasing temperature of 200℃, 400℃, 600℃, 800℃ for 1 hour period. A total of difference percentage of POFA which are 0%,10%,20%,30%,40%.These specimen were subjected by air cooling method. The compressive strength was found higher in 10% of POFA concrete than the normal concrete. Meanwhile the weight loss is high in 40% of POFA concrete at 800℃.In addition, the higher the temperature, higher discolouration and cracking of the concrete.

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LIST OF SYMBOLS

%	Percentage
Kg	Kilogram
Mpa	Megapascal
℃	Celcius
mm	Milimeter
m	Meter

LIST OF ABBREVIATIONS

POFA	Palm Oil Fuel Ash
POBS	Palm Oil Boiler Stone
LWAC	Lightweight Aggregate Concrete
LWC	Lightweight Concrete
$Ca(OH)_2$	Calcium hydroxide
CSH	Calcium Silicate gel
OPC	Ordinary Portland Cement
CO_2	Carbon Dioxide

CHAPTER 1

INTRODUCTION

1.1 Introduction

The development of lightweight concrete (LWC) has been successfully implemented in the construction industry for 30 years and widely used for conventional structure especially when the soil is in poor condition. The development of LWC provides many advantages to construction industry such as cost reduction and environmentally friendly material. To form LWC, a few material of normal concrete were replaced or mix with some other waste material such as palm oil fuel ash (POFA) and palm oil boiler stone (POBS). The utilization of POFA in form of concrete as a partial cement, meanwhile the function of POBS is partial coarse aggregate. By including these materials it can reduce the uses of raw material such stone for aggregate and cement.

The cement processing will lead to air pollution due to high amount of carbon dioxide released from the factory, thus it not good for human health and environment. According to (Karim, Zain, Jamil, & Lai, 2013), Conventional OPC concrete is one of the most versatile and extensively used construction materials in the world. The global cement production reached to 2.9 billion tons annually and it is predicted to increase to 4 billion tons by 2020. The production of one ton of OPC liberates approximately one ton of CO_2, which increase the global warming. It was estimated that 7% of the CO_2 emissions in the world are due to the production of OPC. Thus OPC contributes to climate change, which is an environmental issue, that affects the current and future generations. Due to the effect of cement process, in construction industry the idea of sustainability in construction industry encourages the use of waste material such as POFA, POBS, palm oil shell and other materials to replace raw material such as cement, fine aggregate and coarse aggregate.

Malaysia and Indonesia produces almost 80% of the total palm oil in the world and more than 90% of the total productions are exported. In the year 2011, there were about 410 palm oil mills in Malaysia (chiew, Iwata, & Shimada, 2011).Regarding to the large amount of the POFA generate from industry, the government need to allocate more hectares of landfill for disposal and spends a lot of money for transporting the waste and also the maintenance. Hence, to reduce the cost involve, many authorities are working to have a privilege of reusing and recycle wastes in environmentally and economically sustainable ways. According to that, the utilization of waste material in construction is one of the alternatives taken.

Fundamental issues related to the impact of high temperature on concrete involve identification of the complex changes that take place in concrete while heated. At structural level, the behaviour of the material is characterized by spalling with most cracks parallel to the heated surface. Characteristics such as colour, surface texture, density, volume, compressive strength and elastic modulus are affected remarkably upon heating resulting in a decrease in structural stability of the concrete (Lin ,2011). In addition, the chemical composition and physical properties of the concrete changes significantly at elevated temperature. Over the years extensive research works have been carried out to study the behaviour of concrete at high temperature. Type of concrete materials, moisture condition and the extent of fire has been shown to largely affect the severity of damage to the structure to improve fire.

1.2 Problem Statement

As one of the major palm oil producers in the world, Malaysia produces large amount of waste namely palm oil fuel ash (POFA) and there are over 4 million tonnes of palm oil fuel ash produced in Malaysia. The disposal and combustion of POFA causes environmental pollution and attracted criticisms due to its carcinogenic and bio-accumulative effect. The ash can get easily carried by wind and the smog in humidity causes health hazard. Next is cement. The process of cement production produces high amount of carbon dioxide which it lead to the global warming. Approximately 5% of total CO_2 emission is released to atmosphere, with about 0.7–1.1 ton of CO_2 being emitted for every ton of cement production (Sooraj, 2013). Furthermore, due to the development and high demand in cement, this contributes towards an increase quantity in use of raw material because cement is produced from calcium carbonate. According

to the problem occur by success in integrating POFA in lightweight aggregate concrete as partial cement replacement would reduce cement and palm oil disposal.

1.3 Objective

The objectives of the research are as follow

a) To investigate the effect of air cooling method on weight loss and colour of the lightweight concrete with POFA subjected to elevated temperature

b) To determine the impact of air cooling method on compressive strength of the lightweight concrete with POFA subjected to elevated temperature.

1.4 Scope of study

This experimental work carried out to determine the effect of air cooling on the performance of lightweight concrete containing palm oil fuel ash (POFA) exposed to the high temperature. In order to study the effect of POFA towards the concrete were be investigated by produce the cube concrete that be cured in water for 28 days. Therefore, after 28 days the concrete were be tested for fire resistance test to determine the properties of the concrete after exposed to the high temperature by using air cooling method in term of its colour, compressive strength and weight. There are 5 difference percentage of palm oil fuel ash being used which were 0%,10%,20%,30%,40%.Beside that, this experiment also use different value of temperature which are 200℃,400℃,600℃ and 800℃.There were 60 cubes of 100mm x 100mm x 100mm were prepared in this research

1.5 Significance of Research

This study is focusing in produce concrete by using excess by product in Malaysia which is POFA as the partial of cement in lightweight concrete. Utilization of POFA can reduce the use of landfill for disposal waste. In addition, by applying POFA in the concrete we can reduce traffic hazard due to the ash which can easily get carried away by the wind. Besides that, by using the POFA we can reduce the use of cement in concrete which can also lessen the carbon dioxide released to the surrounding and automatically it can reduce pollution, by applying POFA in concrete results in ash being carried away easily by the wind, thus reducing traffic hazard drastically.

REFERENCES

Abdul Awal A.S.M & Shehu Abu bakar, Properties of concrete containing high volume palm oil Fuel ash, *Civil Engineering* 2011 : 7: 54-66.

A.M. Rashad, An investigation of high-volume fly ash concrete blended with slag subjected to elevated temperatures, *Cleaning Production.* 2015: 1-9

Awal ASMA, Shehu IA, Ismail M. Effect of cooling regime on the residual performance of high-volume palm oil fuel ash concrete exposed to high temperatures. *Construction and Building Materials,* 2015;98:875–83.

Awal, A. A., & Hussin, M. W.The effectiveness of palm oil fuel ash in preventing expansion due to alkali-silica reaction.*Cement and Concrete Composites,* 1997:4: 367-372.

Carlos C, Durrani AJ. Effect of transcient high temperature on high strenght concrete. *ACI Material,* (1990). *87*, 47-53.

Chindaprasirt p, H. S. (2007). strength and water permeability of concrete containing palm oil fuel ash and rice husk-bark ash.

Hansen SB, P. R. (2016*). sustainable concrete cointaining palm fuel ash as a supplementary cementitious material*.

Karim, Zain, Jamil, & Lai.. Fabrication of a non-cement binder using slag, palm oil fuel ash and rice husk with sodium hydroxide. *Renewable and Sustainable Energy Reviews,* 2013:385-98.

Karim, Z. (2011). strenght of concrete as influenced by palm oil fuel ash. *Renewable and Sustainable Energy Reviews*

Kim Hung Mo, P. V. Prediction of the structural behaviour of oil palm shell lightweight concrete beams. *Construction and Building Materials,* 2016:102:722-732.

Kim Hung Mo, U. A. Compressive behaviour of lightweight oil palm shell concrete incorporating slag. *Construction and Building Materials,* 2015: 9: 263-269.

U.Johnson Alengaram, B. A. Characteristics of palm oil clinker as replacement for oil palm shell in lightweight concrete subjected to elevated temperature. *Construction and Building Material* 2015;101:942–51.

Lin Y. Hsiao C. Yang H. Lin YF. The effect of post fire-curing on strength velocity relationship for non-destructive assessment of fire damage concrete strength. *Fire Safety* 2011;46(5):178-85

Lim, Ismail MA, Lee HS , Hussin MW, Sam ARM, Samadi M. The effect of high colume nano palm oil fuel ash on microstructure properties and hydration temperature of mortar. *Construction and building Material,* 2015;*93*: 29-34.

Navid Rajnbar, M. M.Compressive strength and microstructural analysis of fly ash/palm oil fuel ash based geo-polymer mortar under elevated temperature. *Construction and Building Materials,* 2014:65:114-121.

Mohammad ismail, M. E. Influence of elevated temperatures on phyiscal and compressive strenght properties of concrete containing palm oil fuel ash . *Construction and Building Material*,2011:25:2358-2364.

Mujah D. Compressive strength and chloride resistance of grout containing ground palm oil fuel ash. *Clean Production,* 2016 ;*112:* 712-22.

Muthusamy, K., Zamri, N., Zubir, M. A., Kusbiantoro, A., & Ahmad, S. W. (2015). Effect of mixing ingredient on compressive strenght of oil palm shell lightweight aggregate concrete containing palm oil fuel ash .

Payam Shafigh, H. b. (2014). Structural lightweight aggregate concrete using two types of waste from the palm oil industry as aggregate. *Cleaner Production,* 2014: 80:187-196.

Peng G, Song B , Zhan G, Jie Z, Xin P, Yu J. Effect of thermal shock due to rapid cooling on residual mechanical properties of fiber concrete exposed to high temperatures. *Construction and Building Material* 2008:22:948-55

Sooraj. Effect of Palm Oil Fuel Ash (POFA) on Strength Properties of Concrete. *International Journal of Scientific and Research Publication*,2013: 3 : 2250 - 3153.

Tangchirapat W, Saeting T, Jaturapitakkul C, Kiattikomol K, Siripanichgorn A. Use of waste ash from palm oil industry in concrete. *Waste Management* 2007;27:81–8.

Tangchirapat W, Jaturapitakkul C, Chindaprasirt P. Use of palm oil fuel ash as a supplementary cementitious material for producing high-strength concrete. *Construction and Building Material* 2009;23:2641–6.

U.Johnson Alengaram, B. A. (2013). Utilization of oil palm kernel shell as lightweight aggregate in concrete. *Construction and Building Materials, vol 38*, 161-172.

Rashad, A. (2015). An investigation of hig-volume fly ash concrete blencec with slag subjected to elevated temperature .

Y.C. Guo,J.H. Zhang, G.M. Chen, Z.H. Xie, Compressive behaviour of concrete structures incorporating recycled concrete aggregates, rubber crumb and reinforced with steel fibre, subjected to elevated temperature.*Cleaning Production*. 2014: 72 : 193-203